

NASA Contractor Report 195334

11-52  
1552  
22 p

# Telecommuting (Work-at-Home) at NASA Lewis Research Center

Saragur M. Srinidhi  
*Sterling Software*  
*Lewis Research Center Group*  
*Cleveland, Ohio*

(NASA-CR-195334) TELECOMMUTING  
(WORK-AT-HOME) AT NASA LEWIS  
RESEARCH CENTER Final Report  
(Sterling Software) 22 p

N94-36396

May 1994

Unclass

G3/82 0013502

Prepared for  
Lewis Research Center  
Under Contract NAS3-26100



National Aeronautics and  
Space Administration



## ***Telecommuting (Work-At-Home) At NASA Lewis Research Center***

Saragur M. Srinidhi

Sterling Software, MS 142-1

NASA Lewis Research Center

21000 Brookpark Road,

Cleveland, Ohio 44135

Phone: (216)-433-8987; Fax:(216)-433-8000

Email: saragur@lerc.nasa.gov

---

**A report on the pilot Work-At-Home project at NASA Lewis Research Center.**

### **Project Team:**

S.M. Srinidhi, D. Wolfe, J. McGuinness

P. Zam, M. Baldizzi, F.N. Goldberg

Telecommunications and Networking Branch

### **Abstract**

This report presents a study in evaluating the viability of providing a Work-At-Home (Telecommuting) program for Lewis Research Center's corporate employees using Integrated Services Digital Network (ISDN). Case studies have been presented for a range of applications from casual data access to interactive access. The network performance of tele-media applications were studied against future requirements for such level of remote connectivity. Many of the popular ISDN devices were characterized for network and service functionality. A set of recommendations to develop a telecommuting policy have been proposed.

---

## *Introduction*

---

It is widely accepted that Personal Communications Services (PCS) represent a family of applications featuring remote access to network-based services. Under this broad description of PCS, "Telecommuting" or otherwise called "Work-At-Home" with Integrated Services Digital Network (ISDN) is now an accepted concept. Telecommuting can provide a person who works at home or in a satellite office the ability to access, use and send back files to a corporate computing environment at speeds up to 64 Kbs using public data networks. For instance a person might retrieve a large spreadsheet or word processing file and then work on that file on a home computer or might use interactive applications and services directly off the remote network.

With data exchanged at rates up to 64 Kbs on each of the two available channels, performance is much improved over modems that are limited to 14.4 Kbs. Security can be maintained by using the ISDN within the applications on the corporate system to allow access from only a particular set of users. This study aimed to provide an economical solution for casual data requirements to telecommuting with interactive services. The proposed connection architectures in this paper conforms to the National ISDN-1 standards promulgated at the TRIP92 meeting by NIST.

The Telecommunications and Networking Branch of the Computer Services Division actively investigated the "Work-at-Home" concept using ISDN. This perspective means that the computer workstation will become the new communication center, combining many existing communication media with new ones, while creating new paradigms for the expression and sharing of ideas. Individuals will gain new freedom in where they work and how they access information. ISDN represents both the logical evolution of communications technology and the convergence of interactive user computing with work environments spanning large geographies. With telecommuting, the need for extensive travel is reduced and promotes a remedy to the issues concerning environmental pollution. It is currently a law in some parts of the country to alleviate problems created by traffic and pollution.

Appendix A provides a brief overview on Telecommuting and elaborates on some of the pros and cons of telecommuting.

---

### *Objectives of this Study*

---

A major goal of this study was to evaluate the potential of Telecommuting as a service offering for Lewis Research Center and in the process identify and recommend issues to be addressed while developing a concise Telecommuting policy.

The Telecommunications and Networking Branch identified pilot users on a variety of platforms from PCs to high-end workstations to implement this concept on a lab-wide scale. Equipment was procured to conduct a controlled study. A survey on the sociological impact of this new work atmosphere was to be established. The ISDN lines, leased from Ameritech, terminated on a terminal server on the lab and interfaced to the campus backbone, thereby providing complete network access to the employee working at home. The employee also had access to the Lewis PBX system through a digital phone that was provided as an integral part of the ISDN system. Feasibility of providing Desktop Videoconferencing was investigated in these trials using state-of-the-art data compression techniques.

---

### *Current Technology Choice*

---

Three technologies currently compete for remote connectivity: V.FAST modems, ISDN and Switched 56 digital connections. Each of these can be used today to bring significantly greater throughput at a reasonable cost. ISDN Basic rate service delivers data on one or two 64-Kbps channels for services of either 64 Kbps or 128 Kbps. Its circuit setup and maintenance signalling is taken out of band to a separate 16-Kbps channel. A summary on ISDN is provided in Appendix B. While V.FAST operate reliably at 28.8 Kbps over standard (analog) telephone lines, Switched 56 provides a time-charged service that delivers 56 Kbps data rate and is an attractive alternate where ISDN is not available. Additionally, a Switched 56 technology is interoperable with ISDN and, over the long-haul, is expected to be replaced by ISDN equipment, which in turn will likely be replaced by ATM in the far-off future.

It should be noted that it is inappropriate to compare the above three techniques for providing remote access. A V.FAST modem with data compression, for example, can deliver 115 Kbps of throughput under right circumstances, which might appear equivalent or superior to

---

ISDN's 128 Kbps or Switched 56 digital line. However, the fact is that compression will increase throughput on all these services.

We discuss below the various scenarios with which we deployed the ISDN service in this study, ranging from a casual connection requirement to a highly interactive application such as near full motion video employing substantial data compression.

We begin with the pilot user selection criteria used to effect the different connection types.

### *Pilot User Selection Criteria*

---

The selection criteria for pilot users in this study ranged from researchers to managers with specific computing platforms and a well defined work attitude. The profile of the four users in this study is reflected below:

A manager was targeted as a part of this study. The data connectivity requirements were less than what a researcher would require but the need for a sustained link was emphasized. Figure 1 illustrates the network path to the LeRC backbone.

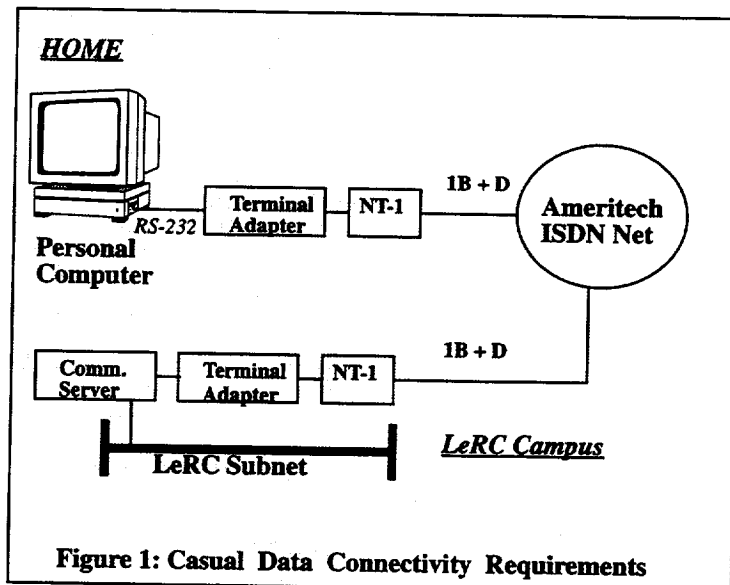
For a research engineer who is required to monitor certain experiments after regular working hours, telecommuting environment would greatly alleviate the need to be physically present on the campus. The remote access with ISDN offers a much higher bandwidth than the fastest dial-up modem that is commercially available today. In this setup, a diskless X-terminal remotely mounted over the ISDN was used to provide the Ethernet extension to the researchers residence. Figure 2 details the network connectivity.

Two engineers from the Telecommunications and Networking Branch were considered to address the technical issues in this effort. A Sun Sparc10 and Macintosh Quadra were employed to effect the connection. The engineers, well versed with tele-media applications, were required to test the ISDN links against these highly interactive requirements.

## Connection Types

### Casual Data Requirements (Configuration: 1B + D BRI)

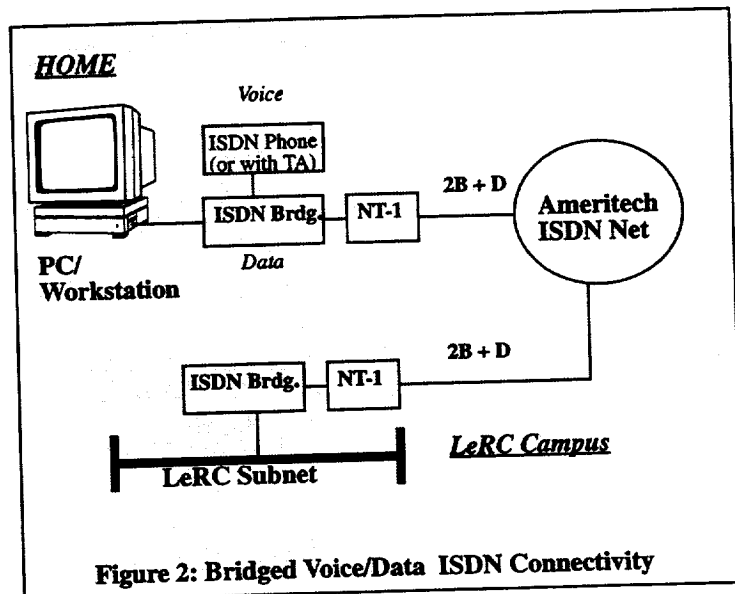
For a casual network access that required access to the Lewis Information Management System (LIMS) through a Laptop Computer, we provided a very cost effective access to the LeRC corporate computing environment using one B channel packet switching at speeds up to 19.2 Kbps (19.2 Kbps was the maximum speed at which one could connect through LeRC telecommunications server). We targeted a corporate manager, in this instance, that required occasional use of services like email or corporate directories. Using a 19.2Kbps B channel call, the telecommuter called into the Communications Server and accessed Telecommuting applications on the Local Area Network (LAN). The Communications Server supports a mechanism for interworking Personal Computers (PC) on ISDN interfaces with other devices on the LAN. The Comm. Server will provide the Call User Data for the server to perform a security screening before allowing the user onto the LAN and can also be configured to accept the ISDN charges for dial-in telecommuting calls on behalf of the computer user. It must be noted here that voice calls can be placed and answered on the B channel while a telecommuting application is run over the D channel. Figure 1 illustrates the concept.



### Interactive requirements (Configuration: 2B + D BRI)

A Lewis Research Center (LeRC) research engineer had access to the computing network via the ethernet and demonstrated very effectively, a specific need for this remote service that otherwise would have required the engineer to be on the LeRC campus. The engineer could monitor and control various production processes remotely. This kind of ethernet access makes sense for situations in which significant information access is expected between the end points but not enough to justify the cost of a leased line. Using the 64 Kb B channel, the telecommuter can call into the ISDN-Ethernet Bridge and access interactive applications on the network. As before, the Bridge will provide the Call User Data to perform a security screening before allowing the user onto the LAN. Voice calls can still be placed and received using one B channel while a telecommuting application is run over the other B channel.

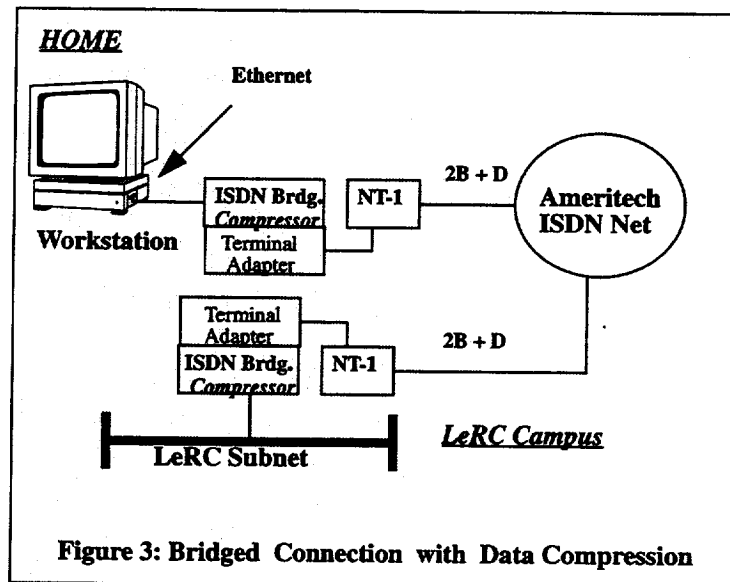
In Figure 2, the Terminal Adapter (TA) together with the analog phone can be replaced with an ISDN phone that has a compatible interface such as RS-232, RS-449 or V.35. The difference in this setup is that the ISDN phone does Packet Assembly and Disassembly (PAD) function supporting CCITT X.3, X.28 or X.29 services.





### High Performance Telecommuting (Configuration: 2B + D BRI)

Communications Analysts from the Telecommunications and Networking branch at LeRC experimented extensively with this interactive access on various computing platforms. Particularly targeted was a Sun workstation and an Apple Macintosh desktop computer. Tests ranging from desktop video conferencing systems to displaying interactive hyper-text retrievals on Mosaic and World Wide Web (WWW) were demonstrated. For multi-media and interactive graphics where data needs to be exchanged at rates of 64 or 128 Kbs, many applications will run almost as fast as they do on the main LAN. Devices that support data compression on the order of 8:1 were used in this connection. In this scheme, when the telecommuter calls in, the corporate computer will refuse the call and then dial back after verifying that access is permitted for greater security. The terminal configuration shown in Figure 3 uses a Personal Computer/Workstation with an external LAN-ISDN Bridge for ISDN access. This application can also be supported if the computer supports an internal line card with both LAN interface functions and LAN-to-ISDN Bridge functions.



## *ISDN Tariffs and Equipment Costs*

Ameritech provided the public ISDN service to the pilot users under a published tariff. The tariffs for direct ISDN service was set at approximately \$45 for the two B-channels with an one-time non-recurring charge of \$150 for installation at each location. Additionally, a service usage charge applied at the rate of \$.01 per minute per B channel. The ISDN user equipment at each location, depending on the type of computing platform employed, ranged from \$1800 (DIGIBOARD IMAC) for a simple 128Kb ethernet access to \$2000 (GANDALF 5220) for devices employing the state-of-the-art data compression techniques (upto a compression ratio of 8:1) to access the ethernet. In the case of the user using the standard serial port on the personal computer to effect an asynchronous connection (dial-up), an ISDN Terminal Adapter sufficed at \$1000. The Network Terminators (NT-1) (made by Motorola and Northern Telecom) used in this experiment was procured at \$500 per device. Table 2 illustrates the cost of each of the test sites.

The cost of the computing platform and associated network host adapter card was not considered in this costing since that would be institutionally provided for the telecommuter. The four pilot users in this study averaged to a monthly usage sensitive charge of approximately \$90 during the span of six months.

**TABLE 1. Equipment and Line cost at remote and LeRC sites**

	<b>Remote Equipment</b>	<b>Site Line Cost</b>	<b>Lewis Equipment</b>	<b>Center Line Cost</b>
<b>Site 1 (Figure 1)</b>	TA - \$1000 NT-1 - \$ 500  (Total - \$1500)	NRC - \$150 RC - \$ 40 Use/Ch - \$0.01	TA - \$1000 NT-1 - \$ 500  (Total - \$1500)	NRC - \$150 RC - \$ 40 No usage recorded
<b>Sites 2/3 (Figure 2)</b>	DigiBoard - \$1800 NT-1 - \$ 500 (Total - \$2300)	NRC - \$150 RC - \$ 40 Use/Ch - \$0.01	DigiBoard - \$1800 NT-1 - \$ 500 (Total - \$2300)	NRC - \$150 RC - \$ 40 No usage recorded
<b>Site 4 (Figure 3)</b>	Gandalf - \$2000 TA - \$1000 NT-1 - \$ 500 (Total - \$3500)	NRC - \$150 RC - \$ 40 Use/Ch - \$0.01	Gandalf - \$2000 TA - \$1000 NT-1 - \$ 500 (Total - \$3500)	NRC - \$150 RC - \$ 40 No usage recorded

### *Implementation Concerns*

---

A number of technical concerns were encountered with Ameritech at the Ameritech Central Office side to get this service operational. Most of the problems were reportedly attributed to the telephone switch incompatibilities between the Central Offices and sometimes non-conformance with the National ISDN standards. It was, however, recognized that this operation was a "first" for Ameritech and they did not have adequately trained technical staff to resolve the problems quickly.

We experienced equipment incompatibilities with Motorola's NT-1 devices not being able to work with the DIGIBOARD IMACs. We could not resolve the issue expeditiously with the equipment manufacturer and eventually used Northern Telecom's NT-1 with the DIGIBOARDS.

One of the potential obstacles that were encountered in this effort were the issue of using government equipment in conjunction with the employee's personal property. Specifically, when an ethernet card had to be installed in the telecommuter's personal computer, the question arose as to who would do the installation, configuration and subsequent maintenance of the said equipment. Does the installer bear responsibility for any damage/destruction caused to the employee's machine and/or property? Also, if a malfunction in the card were to damage the employee's personal computer, does the organization bear liability? Another aspect that will require considerable attention as the number of telecommuters grow is the matter of inventory control on government equipment that is moved to an employee's residence. Such questions and perhaps many more will have to be addressed in a concise policy.

### *ISDN Functionality*

---

A technical summary by the category of the ISDN functionality explored in this study is discussed below. During our testing, each B-channel was available at a data rate of 56Kb, one of the peculiarities of the Ameritech ISDN service. The channel eventually provided a 64 Kb rate during the later phase of the experiments. The categories for evaluation ranged from performance, ease of use, to call accounting and systems management.

The DIGIBOARD IMAC is an integrated device that emulates a Terminal Adapter (TA) and an ethernet bridge. The GANDALF 5220 on the

---

other hand is truly an ethernet bridge and requires an external TA to interface to the computing platform. Both of these devices, however, require a Network Terminator (NT-1) to connect to the ISDN service access point.

As a result of actually implementing ISDN connectivity to the home, a great deal of experience was garnered. Since bridging ethernet over ISDN represented most of what was done, it will be the focal issue. Only one user dialed in directly into the Terminal Server at 19.2 Kbps.

## **PERFORMANCE**

### **THROUGHPUT**

We typically used both B channels at 56Kb for a total of 112Kb. The compression, when switched on, worked well averaging 200% for most traffic. Images and packetized video performed even better at up to 500%.

### **DELAY**

This parameter depended on the type of the ISDN equipment used. The DIGIBOARD IMACs that provide ethernet access without employing any data compression reported a "ping" roundtrip delay of about 45 ms. The GANDALF 5220s that ethernet access with data compression show a roundtrip delay of 100 ms. The delay was not influenced when the compression feature was disabled. The larger delay value appeared to offset the compression advantage in certain applications.

## **EASE OF USE**

The user can place the call manually (either using keypad on the physical device or commands executed on the console) or the call can be made automatically when an ethernet frame is seen. The DIGIBOARD IMACS have a frame activation mode that places a call whenever a selected ethernet packet is seen. This is a benefit of having the ISDN and ethernet interfaces in one device. The optional GANDALF Optimizer software supports V.25bis command strings which, if the TA supports, can be used to instruct the TA to place a call. This solution is more costly, more complex, and suffers from being distributed across several physical devices.

## **FUNCTIONALITY**

### **COMPRESSION**

The data compression feature proved to be valuable in several ways. In addition to providing additional capacity the 2 to 1 effective compression ratio could reduce by 50% the connect charges since 1 B-channel could be used instead of two.

### **FILTERING**

Filtering requirements can be quite complex with limited filtering mechanisms. The DIGIBOARDS and the GANDALF 5220 provided both static and dynamic address filtering, protocol filtering and had a large filter table. Areas considered included amount of ethernet packet available to filtering algorithms, inclusion/exclusion capacity and wild-carding.

## **SECURITY**

In extending the work environment to the home we have added another dimension to security concerns for the physical device and security issues associated with a network access. While a number of security mechanisms are available to provide secure access to the ethernet, the security of the equipment which must be placed at the telecommuters home needs to be incorporated in a formal policy.

What level of security exists for calls placed to the device? Options include the ISDN Q.931 Calling Party Access (ANI) element which provides the ability to limit access to a set of calling telephone numbers. Callback has been implemented by several ISDN equipment vendors. Protocol specific options, such as PPPs password scheme, was also available. The devices studied provided ample security to the network being accessed. It was found desirable to restrict access to the device by ethernet address. The maximum number of configurable addresses may be a consideration when setting up a bidirectional connection of groups of devices.

## **CONFIGURATION**

Local configuration was provided by an RS-232 console port on the device. Remote configuration could be provided via a remote telnet session. On devices which provided both local configuration and remote configuration it was found desirable to have as many of the configuration options available as possible to the remote interface. For instance, one of

---

the devices required use of the local interface to configure the SNMP agent. This proves very inconvenient when the user has to lug equipment to and from home.

### **TROUBLESHOOTING**

During initial testing and setup a good D-channel trace is a must. In our situation, a great deal of confusion surrounded basic configuration issues such as the Central Office switch configurations and SPIDs, TEIs, etc. The service provider (Ameritech) did not have established procedures to disseminate such configuration information to the user. One of the pilot users was located far enough from the CO as to require a repeater to extend the ISDN line to his house. It may not be coincidental that this user experienced regular disruption of service when the ISDN interface loses synchronization signals from the CO. The ability to detect and log physical errors on the ISDN interface may be the only means to illustrate a problem to the provider. Status lights were often the only way to remotely diagnose a problem. It would have been helpful if the status lights were more than binary status indicators.

### **MANAGEMENT**

Management of devices can be achieved through implementation of SNMP agents supporting the standard MIB's, vendor MIB's, or both. Both the DIGIBOARD and the GANDALF 5220 were SNMP compliant. SNMP traps generated when calls are placed/disconnected could be used to implement call logging.

### **Campus PABX Upgrade Path**

Once a formal policy on telecommuting is recognized, the telecommuting service can then be provided via the institutional telephone system. This study has been limited to a pilot offering by ordering ISDN service directly from Ameritech. The Lewis campus PABX, currently serviced by the Fujitsu F9600 ISDN compatible switch, can be configured to support ISDN PRI and BRI circuits. The F9600 can accept a PRI trunk from the Central Office and use it in conjunction with BRI circuits coming off of the same system. A total of eight simultaneous BRI circuits can be supported by a single PRI trunk. The F9600 requires the insertion of two circuit boards to support a single PRI circuit towards the Central Office side and one circuit board on the on-campus user's end will provide eight BRI connection. To be able to provide ISDN data transport

through the PABX, an interface device that provides ethernet connectivity to the LeRC corporate backbone must be installed. Switched ISDN at the basic rate for voice service is currently being supported by F9600. A cost benefit analysis against increasing number of ISDN users must be undertaken to influence an ISDN solution on a lab-wide scale using the Fujitsu's F9600.

---

### *Conclusions*

The objectives of this study in evaluating the viability of telecommuting with ISDN were met. Enough data was obtained to articulate a set of recommendations to develop a telecommuting policy. The network performance of tele-media applications was studied against future requirements for such level of remote connectivity. Many of the popular ISDN devices have been characterized for network performance and service functionality. This characterization will help in recommending a specific set of ISDN equipment for users with a particular set of applications.

A sample policy incorporating the results of this study is presented as a guide in the Appendix C.

---

### *Recommendations*

Corporations have serious needs today to connect both their large and small remote sites, and an ever-increasing number of telecommuters, whether connecting from the home, a remote one-person office or from road while travelling. Handling today's remote wide area connectivity needs means relying on the established transmission infrastructure.

Between the failure of slow modems to keep up with applications and the future promise of Asynchronous Transfer Mode (ATM), ISDN, today provides a significant throughput at a reasonable cost to most satellite locations. But should ISDN be a ubiquitous solution for remote access? The answer is no. Not yet, anyway.

ISDN access to telecommuters must be critically justified against the cost of providing such service. For instance, in this study, the ISDN access to the corporate manager was not justifiable since a 14.4Kbs analog modem would have provided comparable service at a much reduced

---

cost. The criteria in this case was the cost of the service over the offered service potential.

The research engineer who was required to monitor and steer a production process demonstrated a definite need for the level of service that only ISDN could offer. The productivity of the engineer along with the added convenience of being able to monitor a mission critical remote process at all times of the day outweighs cost considerations.

Communications Analysts at the Telecommunications and Networking branch have unequivocally shown that interactive video and image transfers are viable with reasonable performance over ISDN. A decision criteria process should be developed to provide such remote interactive sessions to personnel that require this level of connectivity while weighing cost considerations, mission criticality and immediate work impact on a case by case basis.

It is the recommendation of this report that ISDN be seriously viewed as a potential solution for remote access applications. ISDN has definitely more to offer than a Switched 56 or V.FAST connections and is the only solution, at a reasonable cost, to provide packetized video services. More specifically, for WAH offerings on wider scale, ISDN provides a separate channel for voice and data and truly provides an "office" environment for the telecommuters.

### *Acknowledgments*

---

The project team wishes to acknowledge the pilot users Jan Oprea, Branch Chief of the User Services and Consultation Branch (1310), June Thompson, Research Engineer in the Scientific Data Systems and Applications Branch (1370), Dana Wolfe and Michael Baldizzi, Network Engineers in the Telecommunications and Networking Branch (1390) for contributing their valuable time to participate in this evaluation. The team also thanks Roger Schulte, Branch Chief of the Telecommunications and Networking Branch, for being the forerunner in providing this service to the Lewis Community.



## APPENDIX A

### *Telecommuting - An Overview*

---

There is absolutely no technological reason why one could not be reading this report electronically at their homes. There is also no reason why many of the people who report to a supervisor need to be in the same location. One of the major reasons for telecommuting is pure convenience. Japanese firms, for instance, use satellite offices ringing Tokyo to cut the number of workers travelling to the city. This makes it easier for firms to recruit and keep good workers.

The second reason is legal and environmental. The big thrust for telecommuting in Southern California is a mandate requiring firms to cut pollution. The firms have an option to add an electrolytic precipitators to the exhaust pipes of each of its employees automobiles or cut the miles employees travel. This is a classical telecommuting situation.

Thirdly, there are many personal issues at stake. Will a company lose a very productive worker because he or she is required to stay home for a variety of reasons such as illness and pregnancy.

Many progressive companies have set a trend to hire the best and the brightest across wide geographic boundaries. Specifically, many publishing companies hire writers who can work from anywhere at any time the creative urges become evident - as long as there is a phone at hand.

Economic factors also influence telecommuting. Many good workers are available at very low wages in much of the rural areas of United States. They have good work ethics, are unlikely to move for many personal reasons, and would be grateful for any organization that comes to their locale. One does not need to "go to work" but the jobs can and should go to them. Citibank has implemented this concept by moving their collection operations to remote parts of Nevada and South Dakota. The FBI has followed suite by transferring records to economically depressed areas of West Virginia.

But telecommuting is not without disadvantages. The telecommuters may not have access to supplies and equipment and may find it difficult to separate work and home life. It must be realized that telecommuting is not suitable for all kinds of jobs. It has been reported that managers dislike supervising workers that they cannot see.

Formal telecommuting programs are defined as those implemented as company policy by employers. Informal telecommuting requires only the permission of the employee's immediate supervisor. The idea behind telecommuting should not be construed as a means to cut an employee's workload but give them more flexibility in terms of their work environments.

Table 1. summarizes the pros and cons of telecommuting.

**TABLE 2. Issues in Telecommuting**

PROS	CONS
<p><b>Employers:</b></p> <ul style="list-style-type: none"> <li>• Save much needed real-estate at work</li> <li>• Reduce absenteeism</li> <li>• Outreach towards employees with special skills by overcoming limitations of distance and time</li> <li>• Comply with air-quality mandates</li> <li>• Provide round-the-clock service from remote locations.</li> </ul> <p><b>Employees:</b></p> <ul style="list-style-type: none"> <li>• Achieve increased productivity by decreased commute time, less interruptions and a more pleasant casual work surroundings.</li> <li>• Can oversee dependent children and adults while saving on commuting, meals and clothes.</li> </ul> <p><b>Community:</b></p> <ul style="list-style-type: none"> <li>• Reduce air pollution</li> <li>• Conserve energy</li> <li>• Decrease demand on transportation services.</li> </ul>	<ul style="list-style-type: none"> <li>• Telecommuters may not have necessary supplies and equipment</li> <li>• May have too many family interruptions and household distractions</li> <li>• Have no separation of work and home life</li> <li>• Have less interactions with co-workers</li> <li>• Managers dislike supervising workers they cannot see</li> <li>• May promote dispersion of housing, increasing commuting distances</li> <li>• May set up a two-tiered workforce:telecommuters and on-site workers</li> <li>• Not all jobs are suitable for telecommuting</li> <li>• May affect productivity by the seemingly lack of work routine</li> </ul> <p style="text-align: right;"><i>(Source: The Yankee Group, 1993)</i></p>

## APPENDIX B

### *Integrated Services Digital Network - Overview*

---

Integrated Services Digital Networks (ISDN) have been developed to ease integration of all telecommunication services, except full motion video, on one basic digital channel, namely 64 kbps. Whereas 4 kHz is the basic building block of the analog network, 64 kbps is the basic building block of ISDN. The ISDN basic building block is designed to serve, among other services:

- Digital voice
- High-speed data, both circuit and packet switched
- Telex/teletext
- Telemetry
- Facsimile
- Slow-scan video and compressed video

The goal of ISDN is to provide an integrated facility to incorporate each of the services listed on a common 64-kbps channel and/or a combination of 64- and 16-kbps channels. ISDN assumes that an all-digital network is in place up to and including a subscriber's serving exchange or Central Office (CO). It also assumes that the network has implemented CCITT Signalling System No. 7. The most common user access channels in ISDN for residential links have the following transmission structures: a B channel (64 kbps) is the basic rate channel and a D channel (16 kbps) that is exclusively used for signalling and low speed data connectivity to the network. A commercial link however will have a multiple of B channels and a single D channel for control information.

The *basic* interface structure is composed of two B channels and a D channel and is commonly referred to as 2B + D. The D channel at this interface is 16 kbps. The B channels may be used independently of each other (i.e., two different simultaneous connections).

The *primary* rate B channel interface structures are composed of  $n$  B channels and one D channel, where the D channel in this case is 64 kbps. There are two commonly used primary rates composed of

- 1.544 Mbps = 23B + D
- 2.048 Mbps = 30B + D

---

In essence, it is a switched digital service for dedicated, pay-as-you-go applications similar to those that use packet-switched technology. ISDN's main problem is that its availability and cost vary widely. Using ISDN on a long-distance basis can be different from using it with your local phone company. Similarly, line provisioning and installation ease and reliability vary widely. The National Information Infrastructure Testbed (NIIT), is intent on combining distributed computing and communications to demonstrate real-world network applications for ISDN.

## APPENDIX C

### *Sample Telecommuting Policy*

---

Telecommuting, the practice of working at home or at a site near the home instead of physically traveling to a central workplace is a work alternative that this organization may offer to some employees when it would benefit both the organization and the employee.

Telecommuting is not a formal, universal employee benefit but an alternative method of meeting the needs of the company. Since telecommuting is a privilege the organization has the right to refuse to make telecommuting available to an employee and to terminate a telecommuting arrangement at any time.

Employees are not required to telecommute. Employees have the right to refuse to telecommute if the option is made available to them. Employees who do choose to telecommute have the right to cease telecommuting and return to their former in-office work pattern at any time.

The responsibilities assumed by the organization under an agreement must address the following issues detailed in the following sample telecommuting policy:

- The employee's compensation, benefits, work status and work responsibilities will not change due to participation in the telecommuting program.
- The amount of time the employee is expected to work per day or per pay period will not change due to participation in the telecommuting program.
- The employee's at-home work space will be considered an extension of the company work space. Therefore, the organization will continue to be liable for job-related accidents that occur in the employee's at-home work space during the employee's working hours.
- The organization will be liable for injuries or illnesses that occur during the employee's agreed-upon work hours. The employee's at-home work hours will conform to a schedule agreed upon by the employee and his or her supervisor. If such a schedule has not been agreed upon, the employee's work hours will be assumed to be the same as it was before the employee began telecommuting.

- 
- The organization assumes no liability for injuries occurring in the employee's at-home work space outside the agreed-upon work hours. The responsibilities assumed by the undersigned employee under this agreement may read as:
    - The employee agrees to maintain safe conditions in the at-home work space, and to practice the same safety habits in the designated at-home workplace as he or she would in his or her office on the organization's premises.
    - In the case of an injury while working at home. The employee will immediately report the injury to his or her supervisor or to Employee Relations to get instructions for obtaining medical treatment.
    - Restricted access materials such as payroll records will not be taken home without the written consent of the employee's supervisor.
    - The employee will not undertake to provide primary care for a child under 12 years of age during at-home working hours. If such children will be in the home during the employee's at-home working hours, some other individual must be present to provide primary care or those children. However, if a child under 12 is ill, the employee may on a temporary basis provide primary care for that child, subject to the approval of the employee's supervisor.
    - The employee will also not undertake to provide primary care for an elderly adult, who would otherwise require the care of a nurse. while working at home.
    - The employee will work at home during the hours agreed-upon by the employee and his or her supervisor. Changes to this schedule will be reviewed and approved in advance by the employee's supervisor.

The policy on telecommuting must be developed with the full cooperation of the employee's labor union(s).



**REPORT DOCUMENTATION PAGE**Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

<b>1. AGENCY USE ONLY (Leave blank)</b>		<b>2. REPORT DATE</b> May 1994	<b>3. REPORT TYPE AND DATES COVERED</b> Final Contractor Report	
<b>4. TITLE AND SUBTITLE</b> Telecommuting (Work-at-Home) at NASA Lewis Research Center			<b>5. FUNDING NUMBERS</b>  WU-960-30-02 C-NAS3-26100	
<b>6. AUTHOR(S)</b>  Saragur M. Srinidhi				
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b>  Sterling Software 21000 Brookpark Rd. M.S. 142-2 Cleveland, Ohio 44135			<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>  E-8865	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>  National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191			<b>10. SPONSORING/MONITORING AGENCY REPORT NUMBER</b>  NASA CR-195334	
<b>11. SUPPLEMENTARY NOTES</b>  Project Manager, Roger R. Schulte, Computer Services Division, NASA Lewis Research Center, organization code 1390, (216) 433-9390.				
<b>12a. DISTRIBUTION/AVAILABILITY STATEMENT</b>  Unclassified - Unlimited Subject Categories 82, 99, and 62			<b>12b. DISTRIBUTION CODE</b>	
<b>13. ABSTRACT (Maximum 200 words)</b>  This report presents a study in evaluating the viability of providing a Work-At-Home (Telecommuting) program for Lewis Research Center's corporate employees using Integrated Services Digital Network (ISDN). Case studies have been presented for a range of applications from casual data access to interactive access. The network performance of tele-media applications were studied against future requirements for such level of remote connectivity. Many of the popular ISDN devices were characterized for network and service functionality. A set of recommendations to develop a telecommuting policy have been proposed.				
<b>14. SUBJECT TERMS</b>  ISDN; Telecommuting; Work-at-home			<b>15. NUMBER OF PAGES</b> 22	
			<b>16. PRICE CODE</b> A03	
<b>17. SECURITY CLASSIFICATION OF REPORT</b> Unclassified	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b> Unclassified	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> Unclassified	<b>20. LIMITATION OF ABSTRACT</b>	



**National Aeronautics and  
Space Administration  
Lewis Research Center  
21000 Brookpark Rd.  
Cleveland, OH 44135-3191**

**Official Business  
Penalty for Private Use \$300**

**POSTMASTER: If Undeliverable — Do Not Return**

